DEPARTMENT OF TRANSPORTATION
DIVISION OF RESEARCH AND INNOVATION
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Flex your power!
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December 16, 2003

CALL FOR SUBMISSIONS (CFS)
CFS Number 2045DES

California Department of Transportation, Division of Engineering Services 2004-2005 Research Problem Statements

A CONTRACT MAY OR MAY NOT BE AWARDED FROM THIS CFS.

The Division of Engineering Services (DES) of the California Department of Transportation (Department) is requesting research proposals from public research institutions: colleges**,** universities, and government agencies that bring challenging and innovative solutions to the Department's research problems. DES's first annual Call for Submissions (CFS) is based on problem statements derived from customer needs. This CFS focuses on the application of solutions to meet the Department's mission of **improving mobility across California.** This research will specifically address the following Department goals:

- **SAFETY:** achieve the best safety record in the nation
- **RELIABILITY:** reduce traveler delays due to roadwork and incidents
- **PERFORMANCE:** deliver record levels of transportation system improvements
- **FLEXIBILITY:** make transit a more practical travel option
- **PRODUCTIVITY:** improve the efficiency of the transportation system

You are invited to review and respond to this **CFS Number 2045DES**, entitled, **California Department of Transportation, Division of Engineering Services 2004-2005 Research Problem Statements**". The proposals will be submitted in a two-tiered process. We are requesting "pre-proposals" of about 2-4 pages in length. Those proposers who submit successful pre-proposals will be asked to then submit full-proposals of between 10-20 pages in length. Please see schedule in "Proposal Submission/Evaluation process". In submitting your documents, you must comply with the instructions found herein. Reference the attached CFS for detailed information regarding:

- Background
- Research Needs
- Pre-proposal Format and Content
- Questions and Answers
- Pre-proposal Submission / Evaluation Process
- General Information

If you have questions, the contact person for this CFS is:

Saad El-Azazy, Ph.D.,P.E.
Division of Engineering Services
California Department of Transportation
Email: saad_el-azazy@dot.ca.gov
Fax Number: (916) 227-8898

Interested parties should submit documents to:

Saad El-Azazy at saad_el-azazy@dot.ca.gov

OR

California Department of Transportation
Division of Engineering Services
Office of Earthquake Engineering
1801 30th street, P.O.Box168041, MS 09-2/5I
Sacramento, CA 95816

Attention: Saad El-Azazy

This CFS contains the entire terms and conditions relating to the research problem statements, and no other terms, conditions or representations should be considered unless issued in writing as an addendum to this CFS.

Pre-proposals must be received no later than 5:00 P.S.T. on **January 16, 2004**. Full proposals must be received no later than 5:00 P.S.T. on **March 10, 2004**

TABLE OF CONTENTS

Background

The California Department of Transportation (Department) is the manager of interregional transportation services; more specifically, the Department has the traditional role of owner and operator of the 15,000 mile State Highway System. The Department promotes California's economic vitality and enhances its citizens' quality of life by providing for the movement of people, goods, services and information. The Department is responsible for the delivery of the State's Transportation Improvement Program; planning, designing, building, operating and maintaining California's state highway systems. In addition to a changing mix of transportation modes - such as highways, rail, mass transit, bicycle, pedestrian, and aeronautics, the Department coordinates the solutions to complex issues such as land use, environmental standards, and the formation of partnerships between private industry and local, State and Federal agencies to promote productivity, reliability, safety, flexibility and performance in the State of California. For more information see: www.dot.ca.gov

The Department has developed a new research process guided by the Research and Deployment Steering Committee (RDSC). The RDSC, in turn created Program Steering Committees (PSCs) and Technical Advisory Panels (TAPs) to assist them in developing the research agenda and deploying research products.

The functional Divisions lead the PSCs, and the TAPs reside in those Divisions. The TAPs will include technical experts from Divisions, Districts and external agencies. The TAPs developed the enclosed problem statements, and will review and rank resulting research proposals. The PSCs and the RDSC will make the final determination on which proposals will become research projects. With this system, the Department hopes to provide more customer participation throughout the research process, and ownership of research products.

Research Needs

Highlight issues in this CFS are:

- The CFS is organized according to DES 's customers' needs within the Department, including:
  - Structural Design, Construction, and Maintenance.
  - Geotechnical Engineering.
  - Earthquake Engineering.
- Respondents should demonstrate how their pre-proposals would benefit the traveling public and contribute to meeting the five Department goals.
- The CFS identifies important problems that need to be solved, but generally does not specify how those problems should be solved. This will allow proposers the flexibility to propose new and innovative solutions.

- Pre-proposals need to be focused toward implementation of their results to improve transportation. In order to facilitate implementation, proposers are encouraged to engage in collaborations with industrial and public agency partners and to consider
  how the results of their research can be communicated to those who deploy and operate transportation systems ("technology transfer").
- In order to promote synergy among diverse research projects, proposers should consider how their projects could be integrated with other research projects, as well as transportation planning and deployment projects, in specific California regions or corridors.
- Department staff will work with the authors of pre-proposals that are rated favorably in the review process to strengthen the project's implementation effectiveness and to facilitate their integration with other new and ongoing research, planning and deployment projects.
- Multi-disciplinary and multi-campus research teams are encouraged in order to integrate diverse research capabilities.
- In order to promote synergy among diverse research projects, proposers should consider how their projects could be integrated with other research projects, as well as transportation planning and deployment projects, in specific California regions or corridors.
- Department staff will work with the authors of pre-proposals that are rated favorably in the review process to strengthen the project's implementation effectiveness and to facilitate their integration with other new and ongoing research, planning and deployment projects.
- Multi-disciplinary and multi-campus research teams are encouraged in order to integrate diverse research capabilities.

Two-Tiered process

The first stage of the proposal process will be the pre-proposal. Within 30 days of the pre-proposal submittal deadline, the successful proposers will receive a request to submit a formal, detailed full-proposal or notice declining interest in the pre-proposal. The proposer may also receive comments from Department personnel for purposes of technical clarification of the proposed effort, The second stage of the process will be the full proposal, which will most likely fall in the range from 10-20 pages single-spaced (excluding appendices).

Pre-Proposal Format and Content

The pre-proposal will consist of 2-4 pages, and will include a project plan summary, estimated budget and description of the research team. Please see suggested format below. Proposers should include the identification number of the problem statement to which you are responding, project title, the name of the entity submitting the proposal and all project partners.

Project Plan Summary

- Brief summary of the problem, and how proposed research would contribute to solving the problem;

- Method of approach to the problem;
- Anticipated deliverables;
- Preliminary schedule and milestones;
- Steps to implementation, including additional research phases (if required) and a preliminary timeline for the final product.

Estimated Budget

Each pre-proposal must include an estimated yearly and total budget including: proposed number and type of personnel and man-hours of effort and major equipment proposed for purchase.

Research Team

Describe previous experience and training in relevant areas of research (one-two paragraphs). When relevant, highlight the contribution of research collaborations (across disciplines and campuses or with private sector) to the project. Brief curriculum vitae/resumes of the PI and key personnel may be included as attachments.

Questions and Answers

Respondents with questions about the requirements of this CFS must submit those questions in writing to the email address or fax number shown below. Question submittal must include the individual's name, the name and address of the research institution. All questions must be received no later than **January 7, 2004**. Questions will be answered on the Department's Division of Research and Innovation, DRI website by January 9, 2004. (see web link below).

E-MAILED **OR** FAXED TO:
Email address: saad_el-azazy@dot.ca.gov
Fax No.: (916) 227-8898
Attn: Saad El-Azazy

After the deadline for question submittal has passed, written responses to questions will be collectively compiled, and posted on the Department's DRI website. A hard copy of written responses will be provided upon request. Refer to **Schedule**, to get this CFS's schedule of events and dates.:

http://www.dot.ca.gov/research/CFS

Pre-proposal Submission/Evaluation Process

Pre-proposal Submittal, Modification, Resubmittal, and Withdrawal

Pre-proposals may be e-mailed, mailed or delivered by hand. Pre-proposals may **not** be sent by fax machine.

For emailed pre-proposals, the CFS # and Problem Statement # must be in the subject line, and Project Title and Respondent's Name/Research Institution must be in the email text. Respondents are to submit proposals to:

Saad El-Azazy at saad_el-azazy@dot.ca.gov

For mailed or delivered pre-proposals, the following information must be placed on the lower left corner of the submittal shipping package: CFS#, Problem Statement #, Project Title and Respondent's Name/Research Institution. Respondents are to submit an original pre-proposal marked "ORIGINAL" and seven (7) copies of the pre-proposal to:

California Department of Transportation
Division of Engineering Services
Office of Earthquake Engineering
1801 30th street, P.O.Box168041, MS 09-2/5I
Sacramento, CA 95816
Attention: Saad El-Azazy

Respondents submitting pre-proposals may modify or withdraw the pre-proposal at any time prior to the submittal deadline. Such modification or withdrawal of a pre-proposal shall be in writing and submitted by the same person submitting the original pre-proposal.

If the modification requested is only an addition to a pre-proposal, seven (7) copies of the modification shall be submitted in a sealed package, boldly marked "Addition To (project title)", and signed, and addressed the same as the original pre-proposal.

Evaluation Process

The pre-proposal selection will be made by the Department's Technical Advisory Panels (TAPs). Pre-proposals will be screened against the basic evaluation criteria below. Authors of successful pre-proposals will be asked to submit a full proposal.

Pre-proposal Evaluation Criteria

Responds well to problem statement
Meets Department goals and objectives
Cost is reasonable
Is likely to succeed (deployability)

Acceptance and Rejection of Submissions

The Department retains the right to disregard a minor deviation from the requirements and may, at its sole discretion, request supplemental information or clarification of that information submitted.

Negotiations with Selected Proposer

Once a full proposal is submitted, the Department may elect to negotiate with the selected respondent, leading to a written Agreement with the Department about implementing the proposal. Any agreement as a result of this CFS will be subject to all necessary State, Federal and Agency approvals. If an agreement cannot be reached, negotiations will cease and no contractual agreement written or implied will exist. The Department will not reimburse submitting organizations for any costs incurred in the preparation or submission of pre-proposals or proposals, or in the negotiation process.

This CFS shall not commit the Department to negotiate and execute any Agreement. The Department reserves the right to accept proposals that, in the sole judgment of the Department, are in the best interest of the State and regions. The Department reserves the right to reject any or all proposals or to modify or cancel, in part or in its entirety, this CFS.

Confidentiality

Pre-proposal submittals are confidential. Selection committee members shall discuss the evaluation proceedings and content of proposals only with DRI staff and with members of the selection committees. Pre-proposals that are not selected will not be reprinted or used for purposes not pertaining to this CFS process.

Amendments to the Requested Proposal

The Department reserves the right to amend this CFS by addendum prior to the final date of proposal submission.

General Information

Schedule

The schedule related to this CFS is as follows:

EVENT	DATE
CFS available to prospective Respondents	December 16, 2003
Written Question Submittal Deadline	January 7, 2004
Responses to Questions	January 9, 2004
Final Date for Pre-proposal Submission	**January 16, 2004**
Completion of Proposal Evaluations*	February 13, 2004
Final Date for Full Proposal Submission	March 10, 2004
Full proposal selection	June 2004

* By this date all respondents will be notified if their proposal has been selected for development into a full proposal.

Research Problem Statements

This section outlines DES's research needs within the following categories: Structural Design, Construction, and Maintenance; Geotechnical Engineering; Earthquake Engineering.

RESEARCH PROBLEM STATEMENTS

I – STAP01

Analysis of Bridge Structures Crossing Fault Rupture Zones

II – Research Problem Statement

Question: How can we improve and simplify our current design methods to combine the effects of strong ground motion and permanent ground displacement for structures crossing fault rupture zones, without making overly conservative and costly design assumptions to ensure structures meet life safety requirements?

There are situations where highway bridges may have to cross fault zones. In these cases, the bridges should be designed for the effects of ground motions as well as for fault rupture offsets. Comprehensive fault characterization and time-history analyses of bridges for ground motions with permanent ground displacements need to be conducted in order to develop simplified methods for the analyses of bridges.

III – Objective

In order to account for fault rupture offsets, fault characterization and structural analyses with multiple support ground motions are to be conducted. Time-history analyses of bridges for multiple support seismic ground motions are tedious and time consuming. In addition, the methodology for developing multiple support ground motions with fault rupture offsets is not well established.

For ordinary bridges, seismic analysis is conducted by response spectrum approach and the static analysis is used for fault rupture displacement. The question of how to combine the two results from these analyses to approximate the nonlinear behavior of structures has been left to engineering judgments. Conservative assumptions are generally invoked in design by directly adding the two results.

The objective of this study is to develop methodology for rational analysis of the bridges when subjected to fault rupture offsets. The results of this study may reduce the uncertainty in design and may entail cost savings.

IV – Background

A relatively large number of existing bridge structures and pipelines cross earthquake fault zones. Even though a primary effort in planning a land transportation system is to avoid crossing a fault zone, the high density of faults crossing heavily developed metropolitan areas creates the need to have a rational procedure to design new structures and/or widenings, and to retrofit existing bridges that cross fault zones. In this situation, dynamic analysis of these structures for earthquake loading should not only consider the effect of ground shaking but also the effect of ground displacement due to fault rupture. Therefore, there is a need to develop a comprehensive analysis procedure to incorporate the fault rupture effects in the development of multiple support ground motions for major interchanges crossing fault zones. Also, for ordinary bridge structures, there is a need to develop a simplified procedure to include the loads induced by the permanent fault offset with the loads resulting from the ground shaking. Traditionally, this load combination problem has been left to crude engineering judgment.

V – Statement of Urgency and Benefits

Analysis/Design of bridge structures crossing fault zones involve great concerns regarding safety and economic matters. It is clear that these structures are vulnerable to the extreme loads induced by the permanent displacements associated with the fault rupture. A rational analysis/design procedure incorporating fault rupture is needed to obtain cost effective and safe designs. The source of this cost savings is related to the reduced conservatism due to the development of a more rational analysis technique with less uncertainty.

VI – Related Research

Some related research is being conducted under the PEARL Program. However, there is no comprehensive program to provide either a rational, rigorous analysis for complex structures or a simplified design methodology for ordinary bridges.

VII – Deployment Potential

The final product will be a simplified, ready to use methodology to analyze bridge structures crossing fault zones.

I – STAP07

Performance of Isolators and Dampers Under Service and Seismic Loading

II – Research Problem Statement

Question: How do durability, maintenance, and other loading conditions affect the performance of isolation bearings on bridges?

The actual performance of isolation bearings and dampers under different loading conditions such as temperature variation, live loading, and seismic events, requires further study.

III – Objective

- Verify the design assumptions.
- Provide more knowledge about the characteristics of these devices during seismic events as well as in service condition.
- To produce better specifications and design guidelines for future projects.
- Better understanding of these devices will result in improved design that takes advantage of the technical merits of the devices and provides serviceability of bridge structures after major seismic events.

IV – Background

Seismic safety devices such as isolation bearings and dampers are effective at dissipating energy and reducing force demands on the bridge members during seismic events. Isolation bearings and dampers were used in the retrofit of most toll bridges. The functionality of these devices is essential to the performance of the bridges during a seismic event. With limited testing in the construction phase of The Toll Bridge Retrofit Projects, our knowledge about the characteristics of these devices is still lacking. Without more complete understanding of the actual performance of these devices under different loading conditions, their durability and the potential maintenance, designers lack confidence in applying this technology further on new bridge projects.

V – Statement of Urgency and Benefits

There is no immediate urgency but the benefit from this research will immediately provide more useful information to help the designers to consider isolation as one of the valid alternatives for seismic design of bridges.

VI – Related Research

Highway innovative Technology Evaluation Center (HITEC), Summary of Evaluation Findings for the Testing of Seismic Isolation and Energy Dissipating Devices, CERF Report: #40404, July 1999.

VII – Deployment Potential

The product will be a report on the performance of devices under various loading conditions and provide better design guidelines for designers to incorporate into their plans and specifications. This may consequently reduce potential confusion and claims in the construction phase. Some future testing may be needed to study the aging effect of these devices.

I – STAP13

Design Guidelines for Foundation Rocking of Bridge Piers

II – Research Problem Statement

Question: How do we estimate the effects of structure foundation rocking, and how do we incorporate these effects into the design of bridges, to avoid conservative requirements to limit rocking by constructing costly overly large footings to ensure the safety of the structure?

Develop guidelines for foundation rocking of bridge piers based on analytical study and experimental verification.

III – Objective

The research objectives are:

- To study the foundation rocking mechanisms analytically for foundation types, limits of overturning moments, and determination of seismic demands for bridges allowing rocking system;
- To validate analytical modeling for foundation rocking behavior using shake table testing; and
- To develop the design guidelines and procedures for analytical modeling of foundation rocking under earthquake loading.

IV – Background

Current seismic design of a bridge pier/column with a fixed connection to the footing requires the plastic hinge to form in the column away from the footing. This mechanism is used in new design but is rather expensive to achieve in older structures to be retrofitted for enhanced seismic performance. In some situations, rocking is still needs to be evaluated for new structures where spread foundations are used.

Due to the limited amount of data and codified procedures outlining a design methodology for systems permitting rocking, engineers are required to design foundation anchorage systems. This will inherently provide a tension force transfer mechanism and bond the system to the soil. However, foundation anchorage is often very costly, with the greatest monetary penalty coming from retrofit or repair of existing column bases and foundations.

Housner (1963) first introduced the beneficial effects of rocking behavior on seismic resistant SDOF systems. Subsequent research (Meek, 1975; Huckelbridge and Clough, 1978; Priestley et al., 1978; Chopra and Yim, 1985) expanded on Housner’s research and concluded that systems permitting foundation rocking inherently achieved elongated periods and increased damping when compared to their fix-based foundations. Ultimately, these systems experienced lower force demands and better seismic damage control.

Although rocking mechanism has been successfully used in seismic retrofit of SFOBB West Spans, and other Toll Bridges as well as conventional bridges. There is no practical design guidelines provided in the current Seismic Design Criteria. An integrated analytical and experimental study is needed to develop a comprehensive design guidelines and methodology for bridge piers/columns and support frames incorporating rocking behavior.

V – Statement of Urgency and Benefits

Foundation permitting rocking can inherently elongate periods and increase damping when compared to their fix-based foundations. Ultimately, these systems can experience lower force demands and better seismic damage control.

Foundation rocking behavior of bridge piers/columns shall be investigated analytically and experimentally. Practical design guidelines are really needed and shall be included in the Seismic Design Criteria.

Guidelines developed will provide a cost-effective alternative for engineers to design bridge substructures.

VI – Related Research

Alameddine, F. and Imbsen, R., (2202) "Rocking of Bridge Piers Under Earthquake Loading", Proceedings of the Third National Seismic Conference & Workshop on Bridges and Higways.

Chopra, A.K. and Yim, C.S., (1985) "Simplified Earthquake Analysis of Structures with Foundation Uplift", *J. Struct. Eng*., ASCE 111(4).

Housner, G.W. (1963) "The Behavior of Inverted Pendulum Structures During Earthquakes", *Bulletin of the Seismological Society of America*, SSA 52(2).

Huckelbridge, A.A and Clough, R.W. (1978) "Seismic Response of Uplifting Building Frame", *J. Struct. Div*., ASCE 104(ST8).

Meek, J. W., (1975) "Effects of Foundation Tipping on Dynamic Response", *J. of the Struct. Div*., ASCE 101(ST7).

Priestley, M. J. N.; Evison, R. J. and Carr, A. J. (1978) "Seismic Response of Structures Free to Rock on Their Foundations," *Bulletin of the New Zealand Society for Earthquake Engineering*, Vol. 11 (3) pp. 141-150.

VII – Deployment Potential

The research contract will provide a comprehensive design guidelines and procedures for foundation rocking of bridge piers/columns. The design guidelines developed will be included in Caltrans Seismic Design Criteria and used by bridge design engineers. The development of design guidelines will lead to improved safety and great cost saving on the California highway bridge system.

I – STAP14

Continuous Monitoring of the Performance of Isolated Bridges

II – Research Problem Statement

Question: How do we monitor and inspect, while in service, the performance of energy dissipating devices, such as dampers and isolators, to avoid the need for the costly removal of these devices for testing to evaluate their performance characteristics?

Testing of the seismic response modification devices for the Toll Program has been completed, as noted in Table VI-1 below. The majority of the isolation and energy dissipation devices will be installed and hence operational by the end of 2003. Some of these devices have been operational for several years (e.g. Vincent-Thomas Bridge), and with unexpected results. Unfortunately, short of physically removing these devices from the bridge, no inspection procedure exists to evaluate the performance of these devices while in-service. An analytical study of the experimental test results of these energy dissipation devices can identify the service range of critical performance parameters. This information, integrated with an ad hoc program of performance monitoring can anticipate any variation from design characteristics and evaluate the long-term performance of these devices.

III – Objective

A program to monitor the performance of these devices, while in-service is needed in order to anticipate any significant variation of their critical characteristics. The objective of this project would be to develop a methodology to monitor and evaluate the performance of these devices, while in-service. Performance will be evaluated in terms of remaining service life and ability to perform as-designed.

IV – Background

The Division of Engineering Services currently possesses all the test results for the devices tested for the Toll Program at the SRMD Facility at UC-San Diego. In addition, a significant research effort by others in the areas of system identification and non-destructive damage detection has been on-going the past decade. This includes work funded by Caltrans. Given the wealth of information available in the technical literature discussing system identification and damage detection techniques, coupled with the data available describing the condition of these devices as originally tested, development of such a methodology could be accomplished with a modest research effort.

V – Statement of Urgency and Benefits

Currently no procedure exists to monitor and evaluate the performance of isolation bearings and viscous dampers in service on various bridges, including the Toll Bridges. Also, if this work is successfully executed, it will reduce the need to periodically removing the isolation bearings and dampers from the bridges to evaluate their performance. The cost to physically remove these devices could easily exceed $1.0 million for bridges where the devices are not easily accessible. In addition, this work could impact traffic, causing traveler delays and thus reducing mobility.

The spherical bearings on the SFOBB will be monitored in an effort to answer questions generated by an inquiry from a State Senator. This research could prove helpful for that task.

VI – Related Research

1) Caltrans test results of isolation devices and dampers.
2) Jensen, H.A., "A Reliability-based Optimal Design Process for Dynamic Response Modification Devices", in progress, Santa Maria University, Valparaiso, Chile.

Table VI-1: Testing of SRMD Devices for Toll Program

Bridge (Construction Contract)	**Seismic Modification Device**	**Required Prototype Tests**	**Required Proof Tests**	**Testing Completed**
Benicia-Martinez (#04-044023)	Friction Pendulum Bearings	6	22	2000
SFOBB Project 18 (#04-0435U4)	Dampers	3	100	2003
SFOBB Project 16 (#04-0435U3)	Friction Pendulum Bearings	1	5	2001
Coronado (#11-021923)	Elastomeric Bearings	2	52	2001
	Dampers	2	20	2001
Richmond/ San Rafael (#04-0438U3)	Elastomeric Bearings	6	16	2002
	Dampers	4	28	2003

Note: Vincent-Thomas dampers tested by others

VII – Deployment Potential

Inspection procedure for Toll Bridge Maintenance, as well as Structure-Maintenance.

I – STAP29

Effects of Axial Force Variation On Seismic Response of Isolated Bridges

II – Research Problem Statement

Question: How do we verify the effects of vertical load variation on the seismic response of isolation bearings?

The transverse seismic load applied to the deck of isolated bridges introduces a vertical load variation on the isolation bearings of the bridge piers. Shear components transmitted by the isolator could be significantly different, at the same instant, among the multiple devices installed on the same pier. This can introduce an unexpected level of shear forces and torsional components.

III – Objective

A numerical and experimental verification of the above described effect will be studied, with specifically the use of a multi-degree seismic excitation.

IV – Background

Research program in progress at University of Pavia, Italy and University of California San Diego.

V – Statement of Urgency and Benefits

This research is urgent considering the large implementation of isolation and energy dissipation solutions in the country and around the world.

VI – Related Research

1) Caltrans Reports of tests of isolation devices and dampers.

2) P. Ceresa et al. "Effect of Axial Force Variation in The Seismic Response of Bridges Isolated with Friction Pendulum Systems", In progress, University of Pavia, Italy.

VII – Deployment Potential

Papers and conference presentations.

I – STAP50

Bridge Seismic Analysis Procedure to Address Near-Fault Effects

II - Research Problem Statement

Question: How can we more accurately estimate bridge displacements for structures close to active faults in a major seismic event; and how can we determine when our design procedures may not be appropriate and which alternative procedures would most accurately estimate bridge displacements to ensure they meet life safety requirements?

Recent research suggests that Caltrans seismic analysis procedure may underestimate the displacement of bridges close to active faults. Also, there is concern that the very large demands close to faults may exhaust the available ductile capacity of current bridge designs. Caltrans needs to know in what circumstances our analysis procedure may be inappropriate and what alternative procedures can most effectively be adopted by bridge design engineers.

III - Objective

- Study current research on near-fault effects.
- Study current research on behavior of structures due to near-fault effects.
- Develop an analysis procedure that effectively addresses near-fault effects.
- Test the analysis procedure with bridge component models on shake tables.
- Write up analysis procedure based on research.

IV - Background

Caltrans Seismic Design Criteria requires that the seismic demand shall be increased in the long-period range for structures within 15 km of active faults. More research is needed to determine if this criteria is adequate to address near-fault effects.

V - Statement of Urgency and Benefits

Over 50% of California’s bridges are within 15 km of an active fault. It is urgent that we evaluate our analysis procedure before the next large earthquake occurs.

VI - Related Research

- Seismologists have identified additional hazards close to faults (Somerville).
- Researchers have identified problems using an elastic analysis to determine the demands for near-fault motions (Chopra, Miranda, etc.).

VII - Deployment Potential

Designers will have an analysis procedure to accurately determine the demands on bridges due to near-fault effects.

I – STAP55

Revise Design Procedures to Address Vertical Acceleration

II - Research Problem Statement

Question: How do we estimate the effects of vertical ground motion on structures and incorporate these effects into the seismic design of bridges, without causing significant reductions in productivity during the design process?

Many current guidelines and procedures for the design and detailing of bridge structures may not adequately and clearly address the effects of seismic vertical ground motions. A thorough investigation into the effects of vertical ground motions in combination with lateral ground motions, on the seismic response of varied bridges needs to be performed. The research described herein is intended to lead to the development of improvements in design procedures, guidelines, specifications and detailing practices, relating to vertical ground motion and bridges.

III – Objective

The objective of this research is to investigate the effects of vertical ground motions in combination with lateral ground motions, on the seismic response of a variety of different highway bridge structures, subject to a multitude of varied internal and external parameters and constraints. The following parameter variations will be employed:

1. Structure geometry – number of spans and supports;
2. Material composition – structure and subsurface;
3. Structure types, flexibilities, skews and connectivities;
4. Earthquake magnitudes, location, fault types, multiple sources.

The research study would also include the following:

1. Investigate how vertical acceleration ground motions are introduced and combined into Linearly Elastic Response Spectrum Analysis;
2. Perform Linear Elastic Response Spectrum Analyses and Time History Analyses comparisons with varied parameters;
3. Produce recommendations relating to significance;
4. Disclose current design practice and specification deficiencies;
5. Produce recommendations for specifications enhancement;
6. Produce checklists for incorporation into existing design and detailing specifications and guidelines;
7. Produce recommendations for component and interface proportioning and reinforcement detailing;
8. Develop a detailed rigorous analysis procedure for complicated structures in vulnerable regions;
9. Develop a streamlined analysis approach for typical non-complicated bridges in low vulnerability regions.

IV - Background

Current CALTRANS design criteria for vertical acceleration for ordinary bridges calls for the application of an equivalent static vertical load applied to the superstructure to estimate the effects of vertical acceleration. A case-by-case determination on the effect of vertical load is required for non-standard or important bridges. References are made to superstructure bending moment reinforcement distribution and shear friction analysis adjacent to the bents. There is no guidance material relating to bent cap design, column design, footing or CIDH/shaft design. There is no guidance material relating to the effects of reduced axial load on substructure components. There is no guidance material relating to the case-by case determination for non-standard bridges and conditions, or the employment of time-histories. Uncertainties exist for the designer, relating to significance, scope, application and procedures regarding this issue.

V – Statement of Urgency and Benefits

The design engineer may not clearly understand the application, scope and consequences of vertical ground motions in the design of a bridge. As a consequence, designs may be inadequate or overly conservative. Efficiency in design and detailing resulting from this research, will lead to improvements in bridge behavior, use of materials, constructability and bridge management. Efficiency and completeness of design, will lead to significantly reduced post earthquake repair costs, reduced repair time, improved structure life, improved safety and reduced traffic disruptions. The results of this research will have applications in the design of new bridges, as well as in the replacement, widening, strengthening and retrofitting of existing bridges.

VI - Related Research

Research has been conducted by Martin R. Button, Colman J. Cronin, and Ronald L. Mayes, as highlighted in the Journal of Structural Engineering, dated December 2002, entitled “Effect of Vertical Motions on Seismic Response of Highway Bridges”. Research has also been conducted at the University of New York, under the MCEER Highway Project, which led to a document entitled “Recommended LRFD Guidelines for the Seismic Design of Highway Bridges”.

VII - Deployment Potential

This research contract will lead to improved design and detailing guidelines, enhanced specifications and establish rational design procedures for use by the bridge design engineers. Through this research, improvements can be made to bridge designs and details, to enhance public safety, improve bridge response, while potentially reducing costs.

I – STAP87

Design of Bridge Bearings for Seismic Conditions

II – Research Problem Statement

Steel laminated elastomeric bearings, PTFE elastomeric bearings and PTFE Spherical bearings have been used extensively by Caltrans for years. Overall, the Department has had excellent service performance from these bearings. However, seismic performance has not been verified or tested. It is assumed that a moderate to large seismic event will damage the bearings and they will need to be replaced. Unfortunately, bearing damage could compromise public safety, lead to serious traffic disruptions and result in enormous cost to both the Department and local economies.

III – Objective

The purpose of this research is to determine and quantify the dynamic characteristics and establish failure modes of these bearings through full scale under dynamic testing. The results would be used to make recommendations for both service and seismic designs. It is expected that the outcome of this research would be directly applicable to current Caltrans design practices and could be used to update the current Memo to Designers 7-1 and Caltrans Seismic Design Criteria for Elastomeric, PTFE/Elastomeric and PTFE/Spherical bearings. This research directly contributes to the Department's goals of safety, reliability, flexibility and performance.

IV – Background

Service bearings are designed for a variety of deformations produced by thermal expansion of the bridge deck, live load, shrinkage due to aging or pre-stress, misalignment or beam rotation through shear deformation. Under currently accepted design practice, the maximum shear strain developed in the elastomer due to all causes of deformation is not allowed to exceed 50% and the coefficient of friction is low. However, under seismic conditions elastomeric bearings can undergo large rotations and shear strains in the order of 200 to 300% or even higher, while spherical bearings develop high coefficient of friction, high temperature and excessive PTFE wear that is detrimental to bearing integrity.

The increased requirements for bridge bearings during dynamic conditions come from large forces that generate large rotations and deformations. Bearings designed for only service demands will potentially fail.

A brief outline of the minimum testing parameters is presented below for the three commonly used types of service bearings in Caltrans:

Testing Parameters:

A. Steel Laminated Elastomeric Bearing

Contact Surfaces: Rubber to Steel, Rubber to Concrete

Vertical Load: Minimum Pressure 200 psi, Maximum Pressure 1,200 psi

Shape Factor: [5.0, 7.5],

Initial Bearing Rotation: [0°, 1.5°]

B. PTFE/Elastomeric Bearing
Vertical Load on PTFE Disk: Min. Pressure 2000 psi, Max. Pressure 4,000 psi.
Vertical Load on elastomeric pad: Max. pressure 1,200 psi, Shape Factor > 7.5
Initial Bearing Rotation: [0°, 1.5°]
Coefficient of friction

C. PTFE/Spherical Bearing
Vertical Load on PTFE Disk: Min. Pressure 2000 psi, Max. Pressure 4,500 psi.
Initial Bearing Rotation: [0°, 2.5°],
Coefficient of friction.

V – Statement of Urgency and Benefits

Seismic design methodologies for elastomeric, PTFE elastomeric and PTFE Spherical bearings do not currently exist. Although California is a highly seismic state, Caltrans engineers design bearings only for service not for seismic conditions. This research would lead to new design procedures that would result in better structure performance, lower maintenance cost and longer structure life.

VI – Related Research

Related research does not exist to our knowledge.

VII – Deployment Potential

All new bridges would be designed based on the new design criteria. Existing structures could be evaluated for potential bearing replacement and/or bridge repair on case by case basis.

I – GS02

Gathering Additional Information During Routine Pile Load Testing to Optimize Safety Factors and Reduce Construction Costs

II – Research Problem Statement

Question: What additional information can be gathered economically during routine pile load testing that will result in optimum design safety factors and reduce construction costs for all types of pile foundations?

Caltrans annually performs millions of dollars in pile and shaft load tests that provide invaluable information to construction projects throughout the state. In many circumstances, further significant research benefits could be accrued at only minor additional cost if supplemental instrumentation and testing was added. However, since load testing is funded through projects, the scope and funding of the test program is limited to the determination of data critical to that project only. Many opportunities to cheaply develop data that will serve to reduce Caltrans foundation costs in the future go unrealized.

III – Objective

Develop and deploy instrumentation on select projects that provide information on pile or shaft load shedding behavior as well as the determination of end- bearing loads. Instrumentation will also be used to measure bending stresses and deformation on a select number of anchor piles under lateral loads. Data will be evaluated on an on-going basis through the Division of Research and Innovation’s Pile Load Test Database Program.

IV- Background

Load testing piles and shafts is often necessary to confirm design capacities or refine a foundation design. In the case of large shafts, load-testing costs can approach $ 1 million (primarily due to the need for additional reaction shafts). Test programs for large projects can also approach or exceed $1 million. As these costs are funded through project construction budgets, there is an unwillingness to fund anything but a bare-bones measurement of top of pile deflection as a function of increasing axial load. Opportunities to explore *how* a pile or shaft develops its load carrying capacity are lost. Additional instrumentation would allow for the measurement of skin friction and end-bearing in different geological strata. This type of information can be used in future projects resulting in significant cost savings. Furthermore, supplemental instrumentation can also shed light on the impacts of construction techniques (type of drilling mud, duration of open hole, drilling method etc.) that can be used to improve Caltrans specifications.

VI- Statement of Urgency and Benefits

Caltrans continues to perform expensive load-tests while missing opportunities to invest very modest amounts in added instrumentation that will improve our understanding of pile and shaft behavior and lead to cost savings on future projects.

Caltrans typically spends $30 to 40M per year on drilled shafts and driven piles. Modest improvements in design or specifications can result in significant annual savings.

VII-Related Research

University of Florida has been actively developing methods to collect end-bearing data from load-tests employing wireless techniques. There may be opportunity to test deploy this or similar systems as part of this project.

VIII- Deployment Potential

Instrumentation will be deployed by the Foundation Testing Branch of Geotechnical Services. Load-test findings will be archived in the Division of Research and Innovation's Pile Load-Test Database.

I – GS03

Improved Access to Concrete Hinge Diaphragms for Post-Earthquake Bearing Inspection, Repair, and Replacement

II – Research Problem Statement

Question: How can we improve access and the ability to inspect bearings at in-span bridge hinge diaphragms, reduce traffic impacts to repair or replace these bearings following an earthquake, and improve the constructability of hinge diaphragms which are typically congested with high levels of reinforcement?

The research is to test concrete hinge diaphragms using conventional and headed reinforcement. The diaphragms are to be designed based on Caltrans Maintenance requirements such that they are accessible for bearing inspection and replacement. Access openings are to be included in the prototype.

III – Objective

The research objective is to develop and understanding of the fundamental properties of load carrying capacity of hinges described above. These properties include service and ultimate capacities currently needed in the design of hinge diaphragms. Optimization of detailing and the pertinent amount of reinforcement will necessarily be investigated.

IV – Background

Current codes and specifications covering the design of hinge diaphragms are based on the American Concrete Institute requirements for corbel design. These requirements are not adequate to characterize hinges, particularly where access openings are introduced. The current design is ambiguous, as reliable testing data is not available. With the increase in span length and earthquake loading, the size of hinge diaphragms has dramatically increased. This has resulted in changing geometric aspect ratios and an increase of the required reinforcement. The introduction of access openings further adds to the complexity of hinge design and detailing.

V – Statement of Urgency and Benefits

The research is needed to support the design of accessible hinge diaphragms to facilitate both regular and post-earthquake maintenance operations.

VI – Related Research

No directly relevant research available.

VII – Deployment Potential

Results will be used to update and revise guidelines for hinge diaphragm design including the use of access openings next to highly concentrated loads.

I – GS06

Investigation of Flange Failures in Falsework Cap and Sill Beams

II - Research Problem Statement

Question: How can we reduce the likelihood of catastrophic falsework failures associated with flange bending of steel beam falsework caps?

Localized flange bending of falsework cap/sill beams can easily initiate a catastrophic falsework failure. Initial flange bending under a post increases eccentricities that lead to excessive flange deformation that can cause the post to lose support .

III – Objective

1. Develop realistic equations to determine the flange bending capacity under typical falsework post loading. This equation will be incorporated in the California Falsework Manual.
2. Determine the effectiveness of timber blocking, placed between the top and bottom flanges under a typical falsework post, to resist flange bending.

IV – Background

The Offices of Structure Construction has identified local flange bending as a potential falsework safety issue that is not currently addressed in the Department's Falsework Manual. Falsework design and construction are unique, and current structural steel analysis methods used for similar situations in other civil engineering disciplines may not adequately model the load distribution of a falsework post to cap system.

V – Statement of Urgency and Benefits

An established uniform method for calculating flange-bending capacities under a concentrated falsework post load will provide safer falsework systems. Review of multiple falsework failures has indicated this to be the primary mechanism.

VI – Related Research

Considerable work has been done concerning steel stress and stain models. The load mechanism by timber supports has not been well defined and the models that do exist do not agree with each other.

VII – Deployment Potential

The Department's Falsework Manual will be updated based on project results. When adopted by the Offices of Structures Construction, the results will apply to all projects using cap and sill falsework.

I – GS07

Improved Landslide Information Management

II – Research Problem Statement

Question: How can the Department improve response and operations (e.g. methods and technologies) for landslide identification, mitigation, and information management? How can the Department identify faster and/or more cost-effective landslide mitigation options (e.g. evolving analysis, design, construction, and reconnaissance techniques)? How can the Department identify causal factors for landslides?

III – Objective

Conduct research to identify the most effective mitigation design measures; compile case-histories and document best practices; explore the use of innovative data dissemination technologies; and develop hazard maps. This research will directly address the Department's "Reliability" goal to "reduce traveler delays due to roadwork and incidents."

IV – Background

Caltrans has responsibility for over 1200 miles of landslide-prone highway corridors throughout California, with annual maintenance costs over $10 million. Particularly problematic slides lead to $100 of millions in capital expenditures.

V – Statement of Urgency and Benefits

Landslide hazards are a source of large maintenance costs for the Department. Millions can be saved through the development of more effective management tools. The safety of landslide prone corridors can be improved. Research in this area can yield the following benefits:

- Planning – make more informed decisions during project planning phases.
- Response – reduce response times following landslide failures.
- Management – more effective maintenance of highways by having access to geohazard data.
- Mitigation – identify solution alternatives, drawing upon the Department's institutional knowledge.

VI – Related Research

"Corridor Scale Landslide Hazard Assessment Project" (in progress); "PenMap Demonstration Project"(completed 12/02); "CalNail: California Soil Nail Information Management System" (in progress).

VII – Deployment Potential

Landslide hazard maps, planning guidelines, database of landslide case-histories, design/mitigation handbook, reconnaissance tools for mapping, construction guidelines and specifications, synthesis reports to improve understanding of failure mechanisms.

I – GS08

Post-construction Methods to Enhance the Capacity of Pile Shaft/CIDH Foundations to Optimize Safety Factors and Minimize Construction Costs

II – Research Problem Statement

Question: What post-construction methods can be taken to enhance the capacity of pile shaft/CIDH foundations to optimize safety factors and minimize construction costs?

Current Caltrans design procedures and specifications do not consider the potential capacity enhancing benefits of post-grouting pile shafts.

III – Objective

The viability of using post-grouting techniques to increase end-bearing and shaft skin friction would be explored. Guidelines on determining appropriate design parameters and recommended post-grouting specifications would be developed.

IV- Background

When drilled shafts are constructed in wet conditions (i.e. using drilling slurry), Caltrans does not include any bearing contribution from the shaft tip since the quality of the shaft bottom is likely to be compromised . Many contractors, usually in design-build situations, have successfully employed post-grouting techniques to increase the capacity of shafts. Post-grouting can occur at the bottom of the shaft (to increase end-bearing) and along the sides of the shaft to increase side friction. Utilization of this technique at Caltrans could lead to smaller shaft designs resulting in significant cost savings.

V- Statement of Urgency and Benefits

Caltrans typically spends $15M to $20M each year on drilled shaft foundations. Modest improvements in design or specifications can result in significant annual savings.

VI-Related Research

University of Nevada-Reno recently performed a small analytical study of the effects of post grouting on shaft end-bearing. The study suffered from a lack of field test data, however.

There may be an opportunity to cost share with another proposed pooled-fund project “Validation of Alternate Pile Load Test Methods”. In this case, one set of drilled shafts could be constructed for both projects. The load-testing of the shafts (before and after post-grouting) could be performed using load-test equipment already being utilized in this other project. Combining these projects could result is considerable cost savings.

VII- Deployment Potential

Project results would be deployed through enhanced design procedures and specifications.

I – GS10

Shortening Closure Pour Waiting Time for Bridge Construction

II – Research Problem Statement

Question: Can a time savings be realized in the construction of closure pours for different bridge types, as this then translates to shorter construction periods, cost efficiencies and reduced traffic exposure?

The excessive waiting time for constructing a widening or joining together new phased construction has been a concern of Bridge Construction Engineers for many years. The current requirement for a sixty-day waiting period is typical for all bridge types. Some bridge types may not need such a long waiting time. Research is necessary to determine how to shorten the closure pour waiting time for bridge construction, thus reducing construction time and public impact.

III – Objective

The objective of this research is to study the effects/impacts of shortening the closure pour waiting time when constructing bridge widening or phased projects requiring closure pours.

The result of this research would be to establish updated criteria to shorten the long waiting time for closure pours based on bridge type; e.g., slab bridges, CIP reinforced concrete bridges, etc. Critical criteria such as concrete strength and Young's Modulus will be considered in the analysis. The study should be based on current best practice and technology. Theoretical and experimental investigations may be included. All types of bridge structures should be included in the study. Different closure pour waiting periods may be concluded for varying types of bridge widening and phased construction.

IV – Background

As far as we know, the statement "Closure pour shall not be placed sooner than sixty days after the falsework has been released" is based mainly on past historical graphical data measuring total long-term deflection for cast-in-place post-tensioned (CIP P/S) concrete box bridges. These charts are very general in nature and may not be applicable to other bridge types, leading to excessive waiting periods. The Caltrans' "Bridge Memo to Designers Manual" present two alternative time requirements for falsework release and closure pour placement when a bridge widening is constructed. These two alternatives are listed on Caltrans Structure plans as follows:

<u>FALSEWORK RELEASE</u>

Alternative 1:

Falsework shall be released as soon as permitted by the specifications. Closure pour shall not be placed sooner than 60 days after the falsework had been released.

Alternative 2:

Falsework shall not be released less than 28 days after the last concrete has been placed. Closure pour shall not be placed sooner than 14 days after the falsework has been released.

When falsework release Alternative 2 is used, camber values are 0.75 times those shown.

There are two major potential benefits to shortening the closure pour time to something less than the sixty days generally used; they are as follows:

Public safety and driver inconvenience: Temporary k-rail are usually placed adjacent to traffic to protect widening construction from vehicular impacts. Bridge widening is more typical in congested urban areas than in rural locations, and k-rail placement often narrows traffic lane widths, thus restricting traffic flow during construction. This restriction impedes normal traffic flow and poses a safety hazard to vehicular and often pedestrian traffic. The longer the falsework and k-rail remains, the more the traveling public is at risk. The current requirement for a sixty day waiting period is general for all bridge types and some bridge types may not require such a long waiting time for closure pour.

Working days and construction cost: By shortening the sixty day waiting time for closure pours, Caltrans and the Contractor will be able to reduce the construction period, which will save money for the State and will also address the current pressure by State and local agencies to open projects more quickly to the traveling public.

V – Statement of Urgency and Benefits

The study is needed immediately. The benefit is time-efficiency, cost effectiveness, enhanced public safety and minimized the construction impact to the public traffic.

VI – Related Research

Unknown

VII – Deployment Potential

The results would be incorporated into the design manuals and procedures to give bridge engineers guidelines to shorten closure pour waiting time, which will immediately benefit the bridge construction.

I – GS11

Replacement Alternatives for Deteriorated Approach Slabs

II – Research Problem Statement

Question: Can Fiber Reinforced Polymer composite panels or precast concrete panels be utilized to enhance the service life of bridge approach slabs and decrease the time required to replace deteriorated approach slabs with conventional construction techniques, thus greatly reducing related rehabilitation expenditures and traffic exposure to construction work zones?

Evaluation of prefabricated Fiber Reinforced Polymer (FRP) composite bridge decks or Precast-Approach slabs as replacement alternatives for deteriorated approach slabs.

III – Objective

Determine an effective method and conduct tests to evaluate the feasibility of using prefabricated FRP composite bridge deck panels or precast approach slab elements to replace deteriorated approach slab pavement. This research would provide a means to quickly replace deteriorated approach slabs while reducing the number of lane closures and delays to the traveling public. Additionally, this study will investigate parameters such as anchorage details, substrate preparation, and durability. Two alternative methods addressing the Department's goal to reduce project construction time are proposed:

- Alternative (A) uses prefabricated FRP composite deck panels. The advantages to this method are that the FRP deck panels are off the shelf, can accommodate many approach slab geometries, can be trimmed to fit in the field, are corrosion and fatigue resistant, and are light weight for easy installation.

- Alternative (B) uses precast approach slab elements. The advantage of this system is that precast elements are of higher quality than cast in place, and precast elements can also be prestressed.

IV – Background

Bridge Approach Slabs, particularly in Climate Area 3, are replaced frequently resulting in additional expenditures and causing traffic disruptions and delays. The main reason for approach slab deterioration is that they are subjected to harsh environmental conditions leading to rebar corrosion. Existing methods of approach slab replacement result in increased exposure of the traveling public, contractor's employees, and the Department's employees to safety hazards, and also result in congestion and traffic delays.

FRP composite deck panels can be supplied in various thicknesses and lengths, are not subject to corrosion or fatigue, are lightweight and can be installed quickly. In addition, the Department has conducted research and demonstrated that severely damaged FRP deck panels can quickly and easily be repaired in place, restoring the as built strength and stiffness using conventional hand tools.

V – Statement of Urgency and Benefits

The main benefit is to reduce maintenance, reduce life cycle costs, and reduced traffic delays.

VI – Related Research

Schuyler Heim Bridge deck replacement Program.

J. Gutierrez, *Repair of a Damaged Fiber Reinforce Polymer Composite Bridge Deck*, Sep. 02, 10th US-Japan Conference on Composites, Stanford.

VII – Deployment Potential

Rapid deployment potential can be immediately after test bed sight is established. Can use off the shelf pultruded deck sections.

I – GS12

Development of Design and Construction Specifications Addressing the Intricacies of Horizontally Curved Post-Tensioned Concrete Highway Bridges

II – Research Problem Statement

Question: How can we improve the design and construction of horizontally curved cast-in-place post-tensioned concrete highway bridges, given the fact that existing State, national and international codes do not provide specific guidance on this challenging detail?

Develop design and construction specifications for horizontally curved post-tensioned concrete highway bridges. California has many post-tensioned concrete highway bridges which are constructed with horizontally curved alignments. The Bridge Design Specifications, along with the AASHTO Bridge Specifications and other United States and International codes, do not contain guidelines for the design and construction of horizontally curved concrete bridges. Bridge designers need a complete specification for post-tensioned concrete bridges to provide design procedures and construction requirements for horizontally curved concrete bridges.

III – Objective

The objective of this research is to develop guide specifications covering the design and construction of post-tensioned concrete highway bridges. The specifications should be based on current best practice and technology. Theoretical and experimental investigations should be included. The specifications should be prepared in prepared in both LFD and LRFD format. Additionally, design examples and details should be developed to illustrate the application of the specifications.

IV – Background

Nearly eighty percent of California highway bridges are cast-in-place post-tensioned concrete bridges, many of which are curved horizontally. In recent years, curved bridge tendons have been observed to translate laterally, damaging the inside face of the girders. Horizontally curved girders have also attributed to torsion at the abutment seat.

V – Statement of Urgency and Benefits

Design and construction specifications for horizontally curved post-tensioned concrete highway bridges are required for California bridges, the largest user of this bridge type in the United States.

VI – Related Research

- A similar research problem statement was proposed to TRB Concrete Committee in 2002 by FHWA jointly with the California and Oregon DOTs, but was not selected.
- A similar research proposal was recommended to the AASHTO Research Committee. It was endorsed by the AASHTO T-11 Committee and was recommended to NCHRP in 2003.
- “Tendon Breakout Failures in Bridges” by Dean Landuyt and John Green, Texas DOT.
- “The Cause of Cracking in Post-Tensioned Concrete Box Girder Bridges and Retrofit Procedures” by Walter Podolny, FHWA.

VII – Deployment Potential

As a result of this research, new design and construction specifications for horizontally curved post-tensioned concrete highway bridges will be established. These specifications will lead to improved safety of the California highway bridge system and eliminate potential repair costs.

I – GS13

Use of Fiber Reinforced Concrete in Bridge Approach Slabs

II – Research Problem Statement

Question: Can the simple incorporation of composite fibers to concrete used in approach slab construction and rehabilitation prove a viable economical solution to increasing the longevity of approach slabs, reducing the costs and traffic impacts associated with their replacement?

This research targets development of the following:

- design methods/guidelines for using cast-in-place (CIP) fiber reinforced concrete for bridge approach slabs, and
- construction specifications for proper application procedures.

III - Background

Bridge approach slabs, particularly those in Climate Area 3, need to be replaced frequently due to deterioration, thereby creating undesirable traffic disruptions. One of the reasons for frequent replacements is that the approach slabs in these areas are subject to harsh environmental conditions. The other reason can be attributed to the pounding action of the approaching and departing heavy trucks, which leads to spalling of the cracked concrete and exacerbates deterioration.

Therefore, there is a need to investigate the use of materials with improved resistance to cracking as well better overall performance in bridge approach slabs**.** In general, fiber reinforced concrete (FRC) has less cracking than conventional concrete and the fibers are corrosion resistant. FRC will reduce the frequency of maintenance and extend the service life of the approach slabs.

IV – Proposed Methodology

It is proposed that several selected approach slabs in Climate Area 3 which are currently slated for upgrade be used as test beds for CIP-FRC. These approach slabs will be monitored for their performance under traffic and environmental loading.

V – Statement of Urgency and Benefits

The main anticipated benefits are reduced maintenance, reduced disruption to traffic and lower lifecycle costs.

VI – Related Research

None related known to the author at this time.

VII – Deployment Potential

This research could lead to improved lifecycle of approach slabs, particularly in harsh environmental areas throughout the State.

I – GS14

Load Capacity, Failure Mode and Design Criteria Investigation of Sand Jacks

II - Research Problem Statement

Question: Are sand jacks, now used widely as integral components in falsework systems with minimal analysis to validate design assumptions regarding their effectiveness in this application, safe? Can design and construction criteria be developed to ensure the continued safety of the motoring public in the vicinity of falsework systems employing sand jacks?

Develop an analysis method and design criteria for sand jacks that could be utilized in both future falsework specifications and the Department Falsework Manual.

III – Objective

The objectives of this research proposal are to:

- Develop a uniform testing procedure and establish best general practice guidelines for both design and construction details of sand jacks;
- Evaluate the ultimate loading that sand jacks can safely support;
- Provide an understanding of sand jack failure modes.

IV - Background

Sand jacks have become a common component of bridge falsework. Not only has the use of sand jacks increased over the years, their depth and size has increased to accommodate progressively larger falsework post design loads. Currently no guidelines or criteria for acceptance have been established governing sand jack use on State contracts. This has resulted in many different sand jack designs being submitted and used by industry, often with varying results. Sand jack design, construction, and most importantly quality varies from one contractor to the next. A number of falsework incidents can, at least in part, be attributed to the use of sand jacks.

V – Statement of Urgency and Benefits

Typical falsework construction details create a situation where the sand jack becomes the weak link in the entire falsework system. Failure of a sand jack has strong potential to trigger a catastrophic falsework collapse. Sand jack research and testing would lead to better and more reliable sand jack details. A proven and consistent performing sand jack would have an immediate and direct result in making falsework construction safer.

VI – Related Research

None found.

VII – Deployment Potential

The Department's Falsework Manual will be updated based on the research results. When adopted by the Offices of Structure Construction, the results will apply to all projects using sand jacks in falsework.

I – GS15

Concrete Bridge Deck Crack Sealing/Filling: An Overview of Research

II - Research Problem Statement

Question: Is spending millions of dollars on methacrylate resin treatments of bridge decks justified?

Develop a report that summarizes the findings of a review of published literature and a synthesis of current practices concerning the use and effectiveness of concrete bridge deck crack sealing/filling with a primary focus on the use of Methacrylate Resin.

III – Objective

The objective of the review is to synthesize the research efforts done and state of the practice for bridge deck crack sealing/filling to aid in the development of Caltrans Guidelines for Bridge Deck Crack Sealing/Filling. The report should address at a minimum:

- In what instances (structure type, age, distress) is crack sealant/filler cost effective;
- The added life/longevity to the structure;
- The various types of crack sealant/filler and their appropriate uses;
- The recommended practice for crack sealant/filler.

IV - Background

Bridge deck cracking is the most common type of deck distress observed on California bridges. Methacrylate Resin, a polymer crack sealant, is the number three work recommendation in the Maintenance Program for bridge structures. There is approximately $124,000,000 in outstanding work recommendations for Methacrylate Resin treatment of bridge decks for State owned structures. As of January 2003, we have 1333 locations with Methacrylate Resin treatment recommended, that amounts to approximately 15% of our inventory of State structures.

V – Statement of Urgency and Benefits

This research is not urgent, but it is the first step toward the development of guidelines that will directly improve the spending of limited dollars on preventative strategies and/or rehabilitation of concrete bridge decks on state owned structures.

VI – Related Research

1. Crack Sealing and Repair of Older Serviceable Bridges using Polymer Sealers, David A. Meggers, Kansas Department of Transportation, January 1998.

Impact of Bridge Deck Cracking on Durability, Jeff Pape and Fouad Fanous, 1998 Transportation Conference Proceedings.

VII – Deployment Potential

The research will produce a report summarizing the findings of published literature and current state of practices. This report will be utilized by the Division of Maintenance, Structure Maintenance and Investigations, to develop Caltrans Guidelines for Bridge Deck Crack Sealing/Filling.

I – GS16

Simplified Test to Estimate Coefficient of Friction on Newly Treated Deck Surfaces

II - Research Problem Statement

Question: What is the skid resistance of bridge decks with methacrylate resin deck treatments?

Develop a method to field test the coefficient of friction on bridge decks that have been treated with methacrylate resin (or other treatment). Existing methods do not provide for availability when the work is performed and thus many bridge decks have an unknown skid resistance when opened to traffic, which is a liability to the Department.

III – Objective

Establish a new simplified coefficient of friction test for field use that will allow measurement prior to opening to the surface to public traffic. This would contribute to the Department's goal of achieving the best safety record in the nation.

IV - Background

California Test Method (CTM) 342 measures the coefficient of friction on concrete surfaces. During rehabilitation of bridge decks methacrylate resin is used to seal cracks within the concrete. A condition after application of the resin is the formation of a "slick" surface that is sanded prior to set to provide a reasonable amount of skid resistance. Deck treatment is often performed at night and timely testing is often impossible to complete. In addition, the current inventory of testing machines used for CTM 342 is aging and the maintenance and replacement parts are becoming increasingly difficult to obtain.

V – Statement of Urgency and Benefits

Current specifications require the treated deck surface to pass CA Test Method 342 prior to opening to traffic. A simplified test would assure project delivery on time and within budget while maintaining an acceptable quality assurance level of the skid resistance value on the newly treated deck surfaces.

VI – Related Research

None known.

VII – Deployment Potential

The Department's California Test Methods Manual will be updated based on project results.

I- GS17

New Potentially More Economical Methods of Foundation Load Testing

II – Research Problem Statement

Question: Do new potentially more economical methods of foundation load testing meet Caltrans' requirements?

Caltrans, along with most other state DOT’s, relies almost exclusively on static axial pile load testing as a means of verifying the capacity of drilled shafts or driven piles. New test methods are now available that promise faster tests at lower cost. Unfortunately, no comparative tests on large diameter piles or shafts have been performed to verify the accuracy and methodology of these new test methods.

III – Objective

Determine the accuracy and range of applicability of alternative load-test methods through a comparative load-test program. Evaluate implementation issues and the cost-effectiveness of each method.

IV- Background

Static axial load testing is the industry standard for determining the load-deflection response of piles and shafts since interpretation of the test results is straightforward and incontrovertible. However, this means of testing is expensive and time consuming. Several less expensive alternate methods have been proposed and utilized, including Osterberg Cells, Statinamic Testing, and High-Strain Dynamic Testing, but these methods have never been validated against static axial load-testing for large piles or shafts. If the accuracy of these alternate methods could be evaluated, State DOT’s would be able to determine their value accordingly and confidently obtain load test information at the most competitive cost.

V- Statement of Urgency and Benefits

Caltrans performs axial load-tests on piles and shafts on a regular basis. Utilization of new test methods, if shown to be accurate and reliable, could lead to significant cost savings (on the order of 20 to 50%).

VI-Related Research

Some research and testing has been performed on new test methods, but mostly on smaller diameter piles and shafts, with no comparison to traditional axial load tests.

There may be an opportunity to cost share with another proposed pooled-fund project “Post-Grouting of Pile Shafts”. In this case, one set of drilled shafts could be constructed for both projects resulting in considerable cost savings.

VII- Deployment Potential

The new test methods, if found to be accurate and reliable, could be performed directly by the Geotechnical Services Foundation Testing Branch with the acquisition of additional equipment. More likely, new test methods will be performed through service contracts.

I – GS18

Optimizing the Design of Large Diameter CIDH Piles in Intermediate Geomaterials

II – Research Problem Statement

Question: How can the Department reduce foundation costs and insure required factors of safety when designing large diameter CIDH piles in intermediate geomaterials? How can the Department optimize the design of large diameter CIDH piles in intermediate geomaterials to insure increased confidence in safety factors and reduce construction costs?

Increase the Department's database for axial and lateral large diameter CIDH pile load testing within intermediate geomaterials (moderately cemented to uncemented sandstones, siltstones, and mudstones). Tests should include load testing of pile shafts with and without end bearing conditions and with pile tip elevation above and below the water table. Verify theoretically calculated geotechnical capacities with actual measured pile load testing results.

III – Objective

Develop additional guidelines for geotechnical personnel regarding reliability of theoretical pile capacity calculations for large diameter CIDH piles within intermediate geomaterials commonly encountered within California. This research would be useful for geotechnical personnel providing bridge foundation recommendations. There is a trend towards increasing the frequency of utilizing high capacity large diameter CIDH piles for new bridges in the state, especially lengthy connectors with long spans with single column bents.

More concise guidelines developed from the research would aide bridge designers and geotechnical personnel.

IV – Background

The Department's database for innovative pile load tests of large diameter shafts within intermediate geomaterial is relatively small and scattered.

V – Statement of Urgency and Benefits

The Department is currently designing numerous long connectors at interchanges to improve traffic flow and relieve congestion. Some of these interchange sites are founded within intermediate geomaterials such as mentioned above. More concise guidelines developed from the research will reduce the overall cost of construction.

VI – Related Research

"Design of Rock-Socketed Drilled Shafts", Ohio DOT
http://www.dot.state.oh.us/divplan/research/FY03ProblemStatements/DrilledShafts.pdf

VII – Deployment Potential

Would be used at interchanges in urban areas with intermediate geomaterials present near or at the surface.